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D. S. Dedrick
Iowa State College

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D. S. DEDRICK

THE history of the progress of any typical American industry is the story of the improvement in the production and quality of the initial product and the evolution from the production of a single basic product to the production of a large number of products. In most instances, the increased number of products is a result of the more complete utilization of the raw materials from which the original product was produced. The impetus behind this transition has been at least two-fold, namely, the development of other industries with the corresponding demand for specialized raw materials, or components for the new industry which the first industry could supply by improving its process or product, and secondly, the competition produced by other concerns within the same industry which dictates that improvement of processing and specialization of product must be carried out in order that a favorable competitive position may be maintained. Thus we have seen the ancient coal industry which existed for a long time as a producer of coal only add coke to its products when the need for that product by the infant steel industry was shown. Later, the by-products of the coking process were collected, fractionated, studied and modified chemically, and today we have the huge coal tar by-products industry with its list of products including the components for dyes, medicines, solvents and many other organic chemicals.

The primary purpose of the early petroleum industry was to provide kerosene to be used as fuel for lamps. The other petroleum fractions were considered to be dangerous or useless and were destroyed. The advent of the automobile changed the emphasis of the petroleum company to gasoline and lubricating oils, and later the aeroplane demanded synthetic, tailor-made gasolines of extremely high octane ratings, and highly specialized lubricants. Hand in hand with the developments of these new fuels and lubricants came the development of fly-sprays, specialized solvents, alcohol, butadiene for synthetic rubber and the plethora of other products which we, in 1947, take for granted as normal products of petroleum refining.

Similar stories of expansion of processing and utilization of more and more of the basic raw materials could be told concerning the meat packing industry, the metals refining industry, the explosives manufacturing industry and many others. The almost incredible number of products produced by the major chemical manufacturers is known to all, yet each of these companies started with single products to supply contemporary needs.

The results of these changes have reflected strongly in our social and economic living. The incorporation of scientific methods of production has resulted in the gradual displacement of hand labor by the more efficient machine labor. Without the creation of new processes and products we should certainly be faced with an extremely grievous unemployment situation. As a single concrete example, it was shown by the Bureau of Agricultural Economics of the United States Department of Agriculture in 1938, that soil preparation, sowing, reaping and threshing of an acre of wheat in the State of North Dakota require just one half the number of man hours as in 1918—only twenty years previously. It is the consensus of opinion in America that the continued existence of free enterprise entails increased production of goods in order that standards of living might be raised and that as goods are produced more efficiently, new industries are created. It takes only a glance at statistics to convince the uninformed of the fact that a high percentage of our present day earnings stem from activities which were unknown a century ago and that the rate of increase of new endeavors is accelerating as time goes on. Thus, competitive business concerns progress by more complete utilization of their raw materials in the production of new products and labor profits by having continued new outlets to insure its continued wages. Parenthetically, it should be noted that present labor-management relations are such that the laboring man is fast becoming a home owner and a responsible citizen of his community, rather than a nomadic individual, drifting from job to job. The writer has no thought of discussing, even if he were qualified, the sociological question of labor-management but he hazards the opinion that at least one major reason for the better social and economic position of the laboring man is due to the stabilization-through-expansion of industry.

The past few years have seen the above mentioned trend toward better husbanding of raw materials and the expansion of the number and type of products taking place in still another of the Nation's major industries—the lumber industry.

In a recent issue of the NEWS, house organ of the Weyerhaeuser Sales Company, there appears a very significant map. The area depicted is that of southwestern Washington wherein is located Mount Saint Helens Tree Farm, source of the logs which supplies the three Longview mills of the Weyerhaeuser Timber Company. Dotted about the various areas of the map are cartoon figures illustrating the phases of logging which are taking place. The unique feature of the map is, however, the series of markers spaced about the periphery of two regions, each of which covers approximately one half of the area of the map. The markers read "1950 Timber Crop," "To be Cut in 1975," "Reserved Until 2000 A.D.," "Re-log in Year 2025," "New Crop Here in 2050," and "Logging Here Now and Again in 100 years." Thus the harvesting plans for the Mt. St. Helens Tree Farm is projected for a century in advance based upon years of study of the area. Barring unforeseen destruction, this half-million acre area should continue to furnish the Longview mills with logs for manufacture into pulp, lumber and other products for centuries to come.

Thus a new era is born. The lumber manufacturers together with the railroad builders, the packers, the steel manufacturers and the other producers and processors of the needs of a fast growing nation during the past century had done their job well. They had invested their capital with great risk and had supplied the nation with the lumber it so sorely needed. The methods used, however, proved to be extravagant although the best that were available at the time. Only partial utilization of the felled tree was made. The unused portions were very obvious and because of their spectacular quantity, the logging interests have been accused of being wantonly extravagant. This accusation is hard to justify. Methods of utilization of the unused portions of the tree had not been developed to the point where logging practice could be other than it was. Recently, the picture has been changing, thanks to new developments, and now the lumber industry can begin to think in terms of performance rather than of a nomadic existence. The perpetual tree farm operating on a sustained yield basis makes possible a harvest of logs in one area for centuries to come. The city of Longview, site of two of the largest sawmill operations in the world (Weyerhaeuser and Long-Bell), is not destined to become a ghost town. Residents may build homes, schools and civic improvements secure in the knowledge that the same resources which produce jobs and revenue for themselves will continue for the benefit of their children.

The handling of timberland as agricultural crop land obviously presents problems. The harvesting must be planned well in advance. Seed trees must be left in strategic spots. Thinning must be done with care and an eye for the future in order that the maximum yield of logs of good size per acre may be attained. These thinnings and logging waste in general, must be removed from the woods in order to reduce fire hazards and to produce space for the new forest to grow. It is well known that the amount of non-utilized material consisting of tree tops, broken or defective logs, excessive stump heights and small trees knocked down in logging, is immense. In 1926-27, A. H. Hodgson of the U. S. Forest Service, reported that in the Douglas fir region of western Washington and Oregon such non-utilized material amounted to six million cords per year, which is double the annual consumption of all the pulp mills in the Pacific Northwest. Since that time, considerable progress has ben made in reducing this amount by the use of portable mills and by bringing more material in from the woods.

However, the clearing of the forests of any sensible amount of unutilized material is a highly uneconomical process, regardless of its desirability, unless the material may be transformed into salable products which may be sold in sufficient quantity and at sufficient price to pay for handling and processing.

Much low value material is produced around a mill also. Bark is slabbed off, removing much good wood in the process; trimmings and edgings are either hogged or burned; sawdust is burned or sold for fuel; and decayed sections are burned. Of late, considerable improvement in the utilization of sawmill waste is shown by the fact that the larger mills no longer use their burners. There was a time when the most characteristic feature of a saw-mill was a pile of burning waste material. This is seen now only among the smaller operators. The more modern mills hog their waste and sell it and sawdust for fuel. Thus, in addition to putting the material to a useful purpose, a major fire hazard is obviated. However, a series of processes whereby the mill wastes could be transformed into products possessing a higher net value than they possess as industrial and domestic fuels would be of distinct economic advantage to the mill management. Due to the highly competitive nature of the lumber business, profit margins are such that all new enterprises must be well grounded economically.

The use of adhesives has made possible the manufacture of plywood, a product which can be made free of defects and which possesses by virtue of its crossbanded construction, strength and dimensional stability, unattainable in the parent wood, regardless of its quality. The use of adhesives has also made possible the preparation of core stock, the manufacture of laminated sections from short pieces. Resin impregnation has made possible the manufacture of curved shapes hitherto unattainable. The relative interest in the use of adhesives as applied to the wood-working industry was shown by the fact that over 200 wood technologists, glue manufacturers, engineers and others, recently attended a two-day conference on radio frequency gluing by the University of Washington School of Forestry.

However, gluing of small pieces of salvage together to form a larger piece of usable stock cannot take care of all of the non-utilized materials. To that end, there has been much activity on the part of chemists, physicists and engineers during the past few years. The activities of the Federally supported Forest Products Laboratory of Madison, Wisconsin, in the field of utilization are known to all of the readers of this article. State-supported Experiment Stations have attacked the problem in most areas of the Nation.

Dean Paul Dunn of the School of Forestry at Oregon State College, writing in the "Oregon Business Review" for 31 October 1944, lists the following projects being studied in the Wood Products Laboratories at that institution at that time: The carbonization of wood waste to produce metallurgical coke and by-products; the modification of lignin to produce thermosetting adhesives and binders for bonded boards; experiments with Douglas fir bark cork and the extraction of tannin and waxes from the non-cork fractions and the utilization of Scholler lignin.

At the Forestry School at the University of Washington, a process for producing butyl alcohol by fermenting wood waste has been announced recently, as has also a thermo-setting resin with a lignin derivative base.

These represent only a few of the studies being conducted by the various land grant colleges and universities in their colleges of forestry and their experiment stations. The writer is not familiar with the projects of the same nature being investigated at Iowa State College, but he is certain, from his experience with the College, that very fundamental studies with far-reaching practical results are being carried out.

The reader is probably familiar with the products from woods and sawmill wastes which have been announced in the press. A partial list would include the fermentation of sulfite waste liquor to produce ethyl alcohol by the Puget Sound Pulp and Timber Company at Bellingham, Washington. A great deal of publicity has attended the building with Defense Corporation funds of the plant at Springfield, Oregon, for the acid hydrolysis of hogged Douglas fir waste and the yeast fermentation of this hydrolyzed material to produce ethyl alcohol by the Scholler process. Operation of the plant by the Willamette Valley Wood Chemical Company is now rumored to be imminent and should present an excellent test of the economics of the process in a country where competition with alcohol from other sources is keen. It will be remembered that German war-time economy depended to a great extent upon the several Scholler installations which were operating for alcohol which was used as fuel, solvent and starting material for organic synthesis, as well as for yeast which was used in quantity for stock feed.

In 1921 the Wood Conversion Company was established at Cloquet, Minnesota, to utilize the saw-mill waste of the then flourishing white pine lumber industry. Timber of saw log size became no longer available in sufficient quantity for continued operation of the saw-mills, but the operations of the Wood Conversion Company were continued with aspen and jack pine pulpwood. Among the activities of this company is the conversion of aspen and jack pine into fiber and fiber structures which are marketed as Balsam Wool, Stalite, refrigerator insulation and other products which are well known to the reader. These products are the result of the activities of the Development Department of the Wood Conversion Company which has been responsible for working out the engineering and scientific details of the process involved.

The progress of the development work at Cloquet interested a sister company, the Weyerhaeuser Timber Company. The need was seen for development work to deal with problems peculiar to that company's operations in the Pacific

Northwest. As the result of the normal growth of the company the opportunity to meet the need came in 1941 when the Development Department was established on the mill site of the Weyerhaeuser Timber Company in Longview, Washington. The present staff at Longview consists of more than forty men, most of whom are experienced as chemical or mechanical engineers, chemists, physicists or product engineers.

An example of the activities of the Longview Development Department is the series of bark products recently announced for sale by the Company and put into full-scale production. As is true with practically all such developments, the incentive came from the needs of an already established activity—the saw-mill in this case. It had long been desired to saw bark-free logs in the mill. This would allow the production of bark-free slabs which could be more economically sold or converted than slabs with the bark on them. Of even greater importance is the fact that the head sawyer would be able to examine the characteristics of the bark-free log to much better advantage and thus he could direct its being sawed to the greatest economic benefit. However, the removal of bark from saw logs is a costly process, regardless of the method used, and so, in order to permit the advantages of barked logs the bark must be utilized in some manner that will pay for its removal. The problem was one of the first to be selected for the new Development Department. Detailed examination yielded the information that Douglas fir bark consists essentially of three components: a flaky corklike material; a fibrous material; and a highly friable amorphous material. It was found that by processing, a set of five different products could be isolated without resorting to chemical transformation. One of these, designated as WT-383, consists of cork particles larger than 28-mesh. Although untreated Douglas fir cork does not lend itself immediately as an alternative material for Mediterranean cork, it has been found to be an excellent soil conditioner and considerable tonnage is being moved for this purpose. A second product, WT-412, consists of a controlled blend of cork and fiber particles. The thermoplastic properties of the cork particles combined with the stiff, strong fibers which orient themselves during flow, make this product a very satisfactory ingredient for phenol-formaldehyde molding compounds, which is its chief outlet at the present time. WT-412F is an almost pure fiber fraction which has been found to have value as an impact producing ingredient in thermo-setting molding compounds. WT-472T is a blend of cork particles, fibers and parenchymous tissue. The unique properties of this product are such as to make it well suited as a chemically active extender for phenol-formaldehyde adhesives used in the Douglas fir plywood industry—a superior material to those commonly used in the past. Still another product, called WT-490, consists of the highly friable parenchymous tissue. The biggest volume outlet for this product at the present time is as the vehicle for dust-type insecticides. These, and many other uses make possible the utilization of a sensible proportion of the bark supply available at Longview. However, one has only to consider the huge quantity of bark associated with the yearly activity of a major saw-mill operation to realize the enormity of the task of utilizing it all. Consequently, other uses are constantly being sought and test operated, either in the Development Department or in cooperation with interested firms in their plants or laboratories. It is an important economic fact that these products, together with those to follow, represent a stable production together with stabilized prices because of the nature and replaceable character of the raw material.

It would, undoubtedly, be interesting to continue the discussion of the various studies which have been completed or which are being currently studied by the staff of this Department, but those who are familiar with industrial research realize that such discussion is not possible. Those who are accustomed to the research policies of peace-time educational institution and government agency laboratories wherein immediate publication of all results is taken as a matter of course and is encouraged, even to the extent of personal advancement being dependent upon the number of publications in many instances, find the secrecy surrounding an industrial research or industrial laboratory difficult to understand. First-hand information, however, makes the justification of this policy quite simple. The establishment and maintenance of a staff, laboratory facilities, pilot plants, technical sales activities and patent counsel, require a great deal of money. Development of a product or process is normally slow, and even with careful planning it is considered axiomatic that approximately ten years of development separate the inception of an idea and the establishment of a commercially successful business. It is only common sense to so operate as to guarantee, so far as possible, the return of the many thousands of dollars spent in development including the establishment of profit-able commercial plants involving both fixed and working capital dollars.

It cannot be too highly emphasized that a stable, large volume market must be achieved as one of the objectives of such development work. The components of wood are very complex, and a clever organic chemist can undoubtedly use a Douglas fir log or parts thereof as the starting material in the synthesis of practically any molecule which he may envision, which is of great interest theoretically, but if a large market for the finished product does not exist or cannot be created to justify the cost of the process, the industrial laboratory is not interested. For example, one frequently hears that wood lignin can be easily transformed into vanillin with good yield. This is true. But at the moment, the quantity of vanillin used in the United States is small, being limited essentially to food flavoring. The amount of lignin available in the waste of a large mill in one day could conceivably supply the demand of vanillin for years. Should it ever be found that vanillin can be used on a tonnage basis instead of on a gram basis as a chemical raw material, then the woods waste laboratories and plants would become definitely interested. It is significant in this respect to note that even with the present sugar situation when many people believe that they are not receiving enough of that product to meet their daily demands, the various sugar growing and marketing organizations are sponsoring extensive research programs in many colleges and universities whereby they hope to vastly increase the use of sugar by making it an industrial raw material rather than a food alone.

The question naturally arises concerning the probable expansion of development work in the lumber industry. It is the opinion of the writer that the next decade will witness research and development as firmly entrenched in the saw-mill industry as it is today in other industries such as steel, petroleum, textiles, foods and so forth. The larger companies will undoubtedly organize and staff their own laboratories while the smaller companies will employ the services of a research institute or finance graduate studies at an institution of higher learning. The change will be made from economic necessity. The saw-mill operator of a generation ago would be quite lost if he were to step on to the lot of a modern saw-mill and note the barkers, the lack of burners and the utilization of waste as it is practiced today; but if he should view the mill of the future with its saw-mill building surrounded by many processing plants for non-lumber products, his reaction might well be one of complete incomprehension.

Those readers who are students will probably be interested in the training and qualifications required for taking part in this new research program. In the first place, most of the work which will probably be done will involve chemical transformation either wholly or in part. Therefore, a knowledge of the fundamentals of organic and physical chemistry is necessary. Many operations will involve the use of physical principles either directly or as applied to the apparatus involved. Two years of training in physics is therefore desirable. Familiarity with production-scale equipment is very desirable and for this reason basic engineering training. Specialization is not necessary because the fields are so broad and the activities are so diverse that special courses will be of but little if any value. These academic qualifications are equalled, if not surpassed, by certain personal qualifications. In development work the investigator must have a very active imagination and be a careful planner of his work. He must possess initiative. He must keep up with the literature in his fields of interest. He must be able to keep more than one project moving at the same time. He must be a "team player" and not a prima donna, because development and research work in modern industry is team work rather than individual effort in most cases. It is most important that the individual be a careful observer because preliminary experiments are often few in number and the acceptance or rejectance of an idea or a process hinges upon the technician's interpretations of the results. He must be personable and must certainly be able to express himself both orally and by means of his written reports. Most of all, he must be completely "sold" on the job he is trying to do, namely, to stabilize the industry by the utilization of all material which would otherwise be waste and in so doing, stabilize his community by creating jobs, creating wealth and making community permanence possible.

The saw-mill of the future will differ much from the one of today. Economics has dictated that a change be made, and research and development will determine what the changes will be. And the taking part in the development of these changes is an exciting adventure.